Exhibit KEDNE/LRK-2

X-Factor Calibration for Boston Gas

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Economic and Litigation Consulting

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1. INTRODUCTION AND SUMMARY

1.1 Introduction

Boston Gas (BoGas) proposes to update the performance based regulation (PBR) plan that applies to its gas distribution services. Under the plan, escalation in the company's average price would be limited by a price cap index ("PCI"). PCI growth would be determined by a formula that includes an inflation measure, an X-factor, and a Z-factor. The design of the PCI would incorporate industry trends in input prices and productivity.

Pacific Economics Group, LLC ("PEG") is the nation's leading provider of energy industry productivity studies. Our personnel have testified many times on productivity research. BoGas has retained PEG to calibrate the X-factor of its proposed price cap index.

This report presents the results of our productivity research. Following a brief summary of the study, Section 2 addresses the role of productivity research in index-based regulation. Key details of our productivity work for BoGas are presented in Section 3. Further details are provided in the Appendix.

1.2 Summary of Research

1.2.1 Total Factor Productivity

A total factor productivity ("TFP") index is the ratio of an output quantity index to an input quantity index. It is used to measure the efficiency with which firms convert production inputs to outputs. The TFP index developed for this study measured the TFP growth trend of the Northeast U.S. gas distribution industry. The growth trend of a TFP trend index is the difference between the trends in output and input quantity indexes. Our output quantity index included trends in the number of customers served and volumes delivered by gas distributors. Our input quantity index summarized trends in the amounts of different inputs that distributors use.

1.2.2 Role of Indexing in Regulation

Indexing plans are a common form of PBR worldwide. They can be based on a solid foundation of economic principle and empirical research. According to index logic, the price trend of an industry that, in the long run, earns a competitive return is equal to its unit cost trend. It is therefore sensible to calibrate a PCI for gas distributors to track the unit cost rend of the gas distribution industry. Index logic also shows that an industry's unit cost trend can be expressed as the difference between its input price and TFP trends.

The appropriate calibration of a PCI depends on the selected inflation measure. BoGas proposes to use the GDPPI as the inflation measure in its PCI. In this case, X-factor should be calibrated to track the difference between TFP trends for the industry and the U.S. economy.

1.2.3 Indexing Research

We calculated the TFP trend of Northeast gas distributors as providers of gas distribution services. Gas distribution was defined to include all gas delivery and customer account and customer information services that distributors provide. Established methods and respected, publicly available data were employed in index development. The sample period was 1990-2000. The year 2000 is the latest for which productivity indexes for the US economy are as yet available. Measures of economy-wide productivity trends are needed to compute the productivity differential.

The industry TFP growth was 0.53% per annum. By way of comparison, the federal government's multifactor productivity index for the U.S. private business sector grew at a an average annual rate of 0.98% over the same period. The differential between the TFP trends for Northeast gas distributors and the U.S. economy is therefore -0.45%.

PEG also calculated trends in input price indexes for gas distributors and the U.S. economy. If there are significant differences between these trends and the PCI uses an economy-wide inflation measure, it may be appropriate to include an inflation differential in the X-factor. The inflation differential would be equal to input price inflation for the economy minus input price inflation for the industry.

PEG's research shows that input prices for Northeast gas distributors grew at an average rate of 3.02% per annum over the 1990-2000 period. The input price trend for the U.S. economy was 3.10% over the same period. The inflation differential is therefore 0.1%.

2. TFP Indexes and Performance-Based Regulation

2.1 TFP Indexes

A TFP index is the ratio of an output quantity index to an input quantity index.

$$TFP = \frac{Output\ Quantities}{Input\ Quantities}. \qquad [1]$$

It is used to compare the efficiency with which firms convert inputs to outputs. Comparisons can be made between firms at a point in time or for the same firm (or group of firms) at different points in time. The indexes we developed for this study measure TFP trends in the gas distribution industry.

The growth trend in a TFP trend index is the difference between the trends in the component output and input quantity indexes.

$$trend\ TFP = trend\ Output\ Quantities - trend\ Input\ Quantities\,. \qquad [2]$$

The output quantity index of an industry summarizes trends in the workload that it performs. The input quantity index of an industry summarizes trends in the amounts of production inputs used. TFP grows when the output quantity index rises more rapidly (or falls less rapidly) than the input quantity index. TFP can rise or fall in a given year but typically trends upward over time.

2.2 Role of Indexing Research in Regulation

The logic of economic indexes is useful in calibrating in BoGas's proposed PCI. Our analysis starts with the principle that the trend in the revenue of an industry that earns, in the long run, a competitive rate of return equals the trend in its costs.

$$trend\ \ Revenue^{Industry} = trend\ \ Cost^{\ Industry} \qquad [3]$$

Suppose, now, that we subtract from both sides of [3] the trend in a measure of the quantity of outputs that the industry provides. Now

$$trendRevenue^{Industry} - trendOutput^{Industry} = trendCost^{Industry} - trendOutput^{Industry} \qquad [4]$$

This is equivalent to saying that the trend in the industry's revenue per unit of output equals the trend in its unit cost.

$$trend\ (Revenue/Output)^{Industry} = trend\ (Cost/Output)^{Industry} = trend\ Unit\ Cost.^{Industry} \qquad [5]$$

The long run character of the principle represented in [3] merits emphasis. Fluctuations in input prices, demand, and other external business conditions will cause earnings to fluctuate absent adjustments in production capacity. Since capacity adjustments are costly, however, they will typically not be made rapidly enough to prevent short-term fluctuations in the rates of return around the competitive norm. The long run is a period long enough for the competitive industry to adjust capacity to more secular trends in market conditions.

This discussion implies that PCIs calibrated to track the industry unit cost trend are consistent with how prices evolve n competitive markets. This is sometimes known as the "competitive market paradigm" for PCI design. In addition, it can be shown that the trend in an industry's *total* cost is the sum of the industry's input price and input quantity trends. It follows that the trend in an industry's unit cost is the difference between the trends in its input prices index and its TFP index.[2]

$$trend\ Unit\ Cost^{Industry} = trend\ Input\ Prices^{Industry} - \ trend\ TFP^{Industry} \qquad [6]$$

A PCI is calibrated to track the industry unit cost rend if it satisfies the above formula.

Appropriate calibration of formula [6] can depend on the proposed inflation measure. Suppose, for example, that the GDPPI is used as the inflation measure. The GDPPI measures inflation in the prices of *final* goods and services in the U.S. economy.

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[2] Here is the full logic behind this result:

$$\begin{aligned} trend\ Unit\ Cost^{Industry} &= trend\ Cost^{Industry} - trend\ Customers^{Industry} \\ &= \left(trend\ Input\ Prices^{Industry} + trend\ Input\ Quantities^{Industry}\right) \\ &\quad - trend\ Output\ Quantities^{Industry} \\ &= trend\ Input\ Prices^{Industry} \\ &\quad - \left(trend\ Customers^{Industry} - trend\ Input\ Quantities^{Industry}\right) \\ &= trend\ Input\ Prices^{Industry} - trend\ TFP^{Industry} \end{aligned}$$

The same indexing logic detailed above suggests that input price inflation of the economy exceeds GDPPI inflation by the economy's TFP growth.

$$trend\ Input\ Prices^{economy} = trend\ GDPPI + trend\ \ TFP^{economy} \qquad [7]$$

A PCI that uses the GDPPI as an inflation measure and tracks the industry unit cost trend then satisfies the following formula.

$$\begin{aligned} trend\ PCI &= trend\ Input Price^{industry} - trend\ \ TFP^{industry} \\ &= trend GDPPI + trend TFP^{economy} - trend TFP^{industry} \\ &\ \ + \left[trend\ Input Price^{industry} - \left(trend\ GDPPI + trend\ TFP^{economy}\right)\right] \\ &= trend GDPPI - \left[\begin{array}{l} \left(trend\ TFP^{industry} - trend TFP^{econcomy}\right) \\ + \left(trend\ Input Price^{economy} - trend\ Input\ Price^{industry}\right) \end{array}\right] \\ &= trend GDPPI - X \end{aligned} \qquad [8]$$

It can be seen that the X-factor is the sum of two terms. One is the productivity differential i.e., the difference between the TFP trends of the industry and the economy. X is larger (slowing price growth) as the productivity differential increases. The second term is the inflation differential. This is equal to the difference between the input price growth trends of the economy and the industry. X is larger (slowing price growth) as this differential increases.

BoGas proposes to use the GDPPI as an inflation measure in its PCI. It is therefore sensible to calibrate its X-factor using the TFP and inflation differentials between the gas distribution industry and the U.S. economy.

3. SUMMARY OF INDEXING RESEARCH

This section presents an overview of our work to calculate the TFP trend of gas distributors in the northeastern U.S. The discussion is largely non-technical. Additional and more technical details of the research are provided in the Appendix which follows.

3.1 Data

The primary source of data used in our gas delivery productivity research has changed over time. For earlier years of the sample period, the primary source was the *Uniform Statistical Report* (USR). Gas utilities are asked to file these reports annually with the American Gas Association (AGA). USR data for some variables are aggregated and published annually by the AGA in *Gas Facts*.

USRs are unavailable for most sampled distributors for the later years of the sample period. Some distributors no longer file USRs. Some that do file USRs do not release them to the public. The development of a satisfactory sample therefore requires that PEG obtain basic cost and quantity data from alternative sources including, most notably, reports to state regulators. Fortunately, these reports are fairly standardized since they often use as templates the Form 2 report that interstate gas pipelines are asked to file with the Federal Energy Regulatory Commission. Other sources of data used in our work primarily pertain to input prices. They include DRI/McGraw Hill; Whitman, Requardt & Associates; the Bureau of Economic Analysis ("BEA") of the U.S. Department of Labor.

Our TFP trend calculations are based on high quality data for 16 Northeastern gas distributors. The Massachusetts Department of Telecommunications and Energy (DTE) accepted a regional definition of the gas distribution industry in the last PBR plan for Boston Gas.[3] This study maintained a focus on regional TFP growth.

[3] The DTE based this decis ion on evidence that costs differed between Northeast gas distributors and distributors in the rest of the nation. As discussed in our companion report, *The Cost Performance of Boston Gas*, PEG's most recent research also finds that there are significantly different costs between Northeast and other U.S. gas distributors.

The sample distributors grouped by region are listed in Table 1. The sample includes most of the region's larger distributors. The table also indicates that the sampled LDCs served about 61% of all gas end users in the Northeast.

3.2 Indexing Details

3.2.1 Scope

Cost figures play an important role in our productivity trend research. The applicable total cost of gas distribution was calculated as gas distribution operation and maintenance ("O&M") expenses plus the cost of gas plant ownership and a share of any common costs. Gas distribution O&M expenses are defined as the total O&M expenses of the distributor less any expenses incurred for natural gas production or procurement. The operations corresponding to this definition of cost include all O&M costs associated with gas delivery to end users, customer account, and information and other customer services of LDCs.

In constructing the input quantity index, we decomposed cost into three major input categories: capital services, labor services, and other O&M inputs. The cost of gas delivery labor was defined as the sum of O&M salaries and wages and pensions and other employee benefits. The cost of other O&M inputs was defined to be O&M expenses net of these labor costs and of gas production and procurement expenses. This category includes the services of contract workers, insurance, real estate rents, equipment leases, and miscellaneous materials.

This study used a service price approach to capital cost measurement. Under this approach, the cost of capital is the product of a capital quantity index and the price of capital services. This method has a solid basis in economic theory and is well established in the scholarly literature.

Table 1

NORTHEAST SAMPLE FOR THE INDUSTRY TFP TREND RESEARCH

Company	Number of Customers (2000)
Boston Gas	542,792
Brooklyn Union Gas	1,191,679
Central Hudson Gas & Electric	63,851
Commonwealth Gas	243,853
Connecticut Energy	164,012
Connecticut Natural Gas	155,641
Consolidated Edison	1,048,357
New Jersey Natural Gas	414,620
Niagara Mohawk	544,075
Orange & Rockland Utilities	118,718
PECO	430,842
People's Natural Gas	353,715
PG Energy	155,992
Providence Energy	172,965
Public Service Electric & Gas	1,621,128
Rochester Gas & Electric	285,944
Sample Total	**7,508,184**
Percentage of Northeast Total	**60.87%**

3.2.2 TFP

The growth rate in each TFP index was the difference between the growth rates in industry output and input quantity indexes. Growth in the output quantity index was a weighted average of growth in the number of customers and gas delivery volumes. Weights were based on the cost elasticities for each output from our econometric research

The growth rate in each input quantity index was a weighted average of the growth rates in quantity subindexes for capital, labor, and other O&M inputs. The weights were based on the shares of these input classes in the industry's total gas distribution cost.

3.2.3 Sample Period

The sample period should be long enough to reflect the industry's long-run TFP trend. A period of 10 years is often deemed to be sufficient to fulfill this goal in regulatory proceedings. Since the most recently available data on the productivity of the US economy are for 2000, and US productivity trends are needed to compute the productivity differential, the sample period chosen for our research was 1990-2000.

3.3 Index Results

3.3.1 TFP

Table 2 and Figure 1 report the 1990-2000 average annual growth rates in the gas delivery TFP and component output and input quantity indexes for Northeast gas distributors. Analogous results are presented for the growth trend of the TFP index for the private business sector U.S. economy

It can be seen that the TFP trend for the gas distribution industry was 0.53% per annum. Output quantity growth averaging an annual 1.42% outpaced input quantity growth averaging 0.89% annually. A 0.98% growth trend was calculated for the multifactor productivity index for the U.S. private business sector over the same period. The TFP differential was therefore -0.45% over the 1990-2000 period.

Table 2

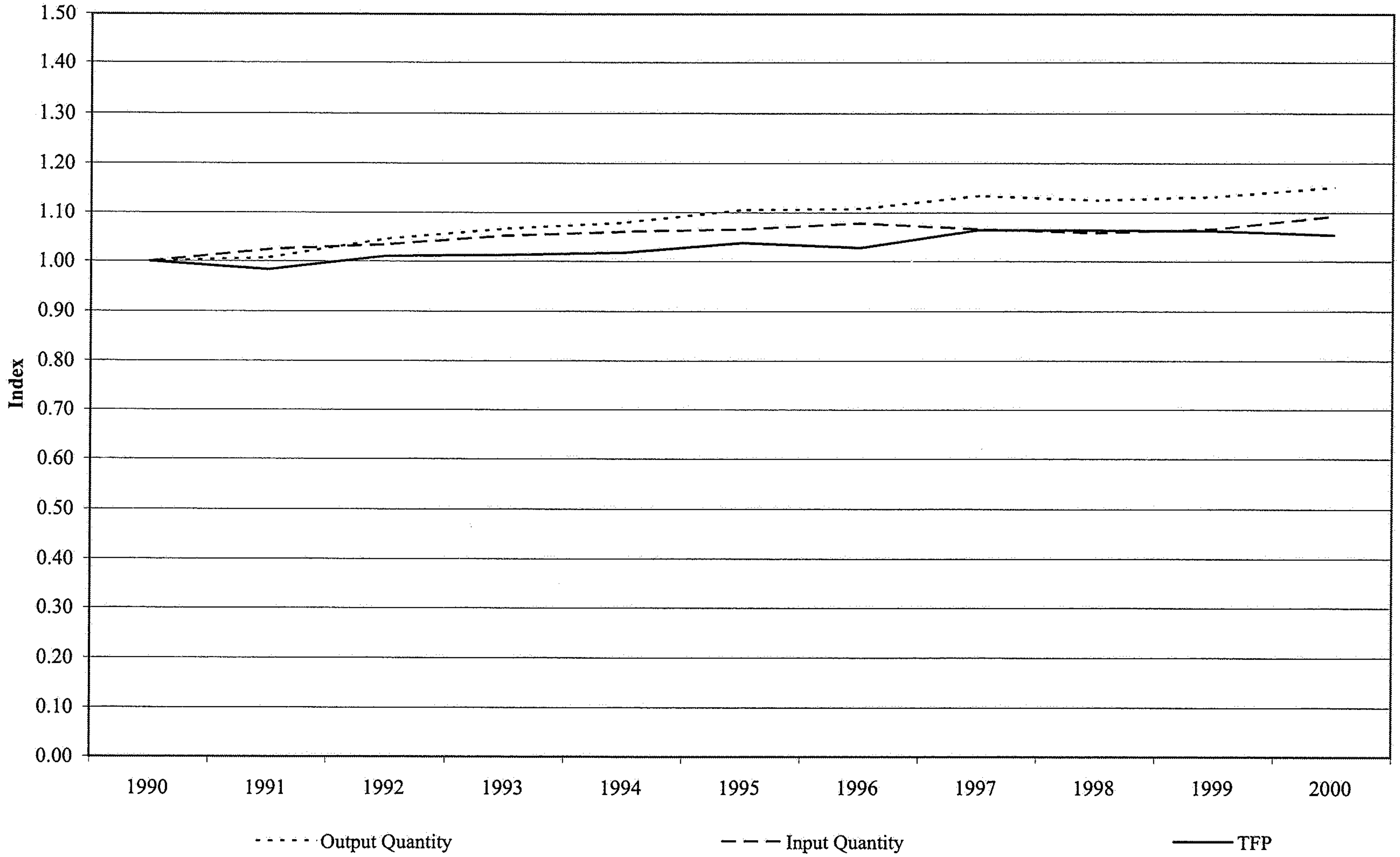
TFP Results:
Northeast Gas Distributors

	Output Quantity Index (A)	Input Quantity Index (B)	TFP Index (C=A/B)	U.S. Private Business Sector*	TFP Differential
1990	1.000	1.000	1.000	95.5	
1991	1.007	1.024	0.984	94.5	
1992	1.046	1.035	1.011	96.7	
1993	1.067	1.052	1.014	97.1	
1994	1.080	1.060	1.018	98.2	
1995	1.106	1.066	1.038	98.4	
1996	1.108	1.078	1.028	100.0	
1997	1.135	1.066	1.064	101.2	
1998	1.126	1.058	1.064	102.5	
1999	1.133	1.067	1.062	103.4	
2000	1.152	1.093	1.054	105.3	
Average Annual Growth Rate 1990-2000	1.42%	0.89%	0.53%	0.98%	-0.45%

* Source: U.S. Bureau of Labor Statistics

Figure 1

TFP Results: Northeast Gas Distributors



3.3.2 Input Prices

Tables 3 and 4 report the 1990-2000 growth trends in input prices for the gas distribution industry and the U.S. economy. In table 3, it is seen that industry input prices grew by 3.02% per annum over the 1990-2000 period.

Table 4 compares this to the input price trend for the U.S. economy. As previously discussed, indexing logic implies that the U.S. input price trend can be computed as the sum of GDPPI growth plus the U.S. MFP trend. It can be seen that, over the 1990-2000 period, this calculation yields an input price trend of 3.10% per annum for the U.S. economy. The difference between the industry and economy-wide input price trends is therefore 0.1%.

Table 3

INPUT PRICE INDEXES FOR THE NORTHEAST U.S. GAS DISTRIBUTION INDUSTRY

	Input Price Index		Labor Price		Capital Price		Non-Labor O&M Price	
	Index	% Change	Index	% Change	Index	% Change	GDP-PI	% Change
1990	1.00		1.00		14.38		86.53	
1991	1.04	4.1%	1.04	3.8%	15.01	4.3%	89.66	3.6%
1992	1.14	9.1%	1.08	3.8%	17.13	13.2%	91.85	2.4%
1993	1.21	5.7%	1.13	4.5%	18.38	7.0%	94.05	2.4%
1994	1.26	4.3%	1.19	4.9%	19.22	4.5%	96.01	2.1%
1995	1.27	0.6%	1.21	1.6%	19.14	-0.4%	98.10	2.2%
1996	1.30	2.6%	1.23	2.2%	19.68	2.8%	100.00	1.9%
1997	1.38	5.7%	1.25	1.7%	21.29	7.9%	101.95	1.9%
1998	1.38	0.1%	1.29	2.6%	21.07	-1.0%	103.20	1.2%
1999	1.41	2.0%	1.29	0.0%	21.60	2.5%	104.66	1.4%
2000	1.35	-4.0%	1.31	1.8%	20.07	-7.4%	107.04	2.2%
Average Annual Growth Rate 1990-2000		3.02%		2.72%		3.33%		2.13%

Table 4

INPUT PRICE INDEXES FOR THE NORTHEAST GAS DISTRIBUTION INDUSTRY AND THE U.S. ECONOMY

	Input Price Index								
	GDP-PI		MFP (Private Business)		U.S. Economy		Gas Distribution Industry		
	Index	% Change[1] [A]	Index	% Change[1] [B]	Index	% Change[1] [C]=[A]+[B]	Index	% Change[1] [D]	Difference[2] [C]-[D]
1990	86.5		95.5		1.043		1.000		
1991	89.7	3.6%	94.5	-1.1%	1.070	2.50%	1.041	4.1%	-1.6%
1992	91.9	2.4%	96.7	2.3%	1.122	4.71%	1.141	9.1%	-4.4%
1993	94.1	2.4%	97.1	0.4%	1.153	2.78%	1.208	5.7%	-3.0%
1994	96.0	2.1%	98.2	1.1%	1.191	3.19%	1.261	4.3%	-1.1%
1995	98.1	2.2%	98.4	0.2%	1.219	2.36%	1.269	0.6%	1.7%
1996	100.0	1.9%	100.0	1.6%	1.263	3.53%	1.303	2.6%	0.9%
1997	102.0	1.9%	101.2	1.2%	1.303	3.12%	1.380	5.7%	-2.6%
1998	103.2	1.2%	102.5	1.3%	1.336	2.50%	1.380	0.1%	2.4%
1999	104.7	1.4%	103.4	0.9%	1.367	2.28%	1.408	2.0%	0.3%
2000	107.0	2.2%	105.3	1.8%	1.423	4.07%	1.353	-4.0%	8.1%
Average Annual Growth Rate 1990-2000		2.13%		0.98%		3.10%		3.02%	0.08%

[1] All computed growth rates are logarithimic.

[2] Statistical tests revealed that the difference of 0.08% is *not* significantly different from 0%.

APPENDIX

This appendix contains additional details of our X-factor calibration work. Section A.1 addresses the input quantity indexes, including the calculation of capital cost. Section A.2 addresses our method for calculating TFP growth rates and trends.

A.1 Input Quantity Indexes

The growth rates of the input quantity indexes were defined by formulas. As noted in Section 3.2, these formulas involved subindexes measuring growth in the amounts of various inputs used. Major decisions in the design of such indexes include their form and the choice of input categories and quantity subindexes.

A.1.1 Index Form

Each regional input quantity index was of Törnqvist form.[4] The annual growth rate of each index was determined by the formula:

$$\ln\left(\frac{Input\ Quantities_t}{Input\ Quantities_{t-1}} \right) = \sum_j \frac{1}{2} \cdot \left(S_{j,t} + S_{j,t-1} \right) \cdot \ln\left(\frac{X_{j,t}}{X_{j,t-1}} \right). \qquad [9]$$

Here in each year t,

$Input\ Quantities_t$ = Input quantity index

$X_{j,t}$ = Quantity subindex for input category j

$S_{j,t}$ = Share of input category j in applicable total cost.

It can be seen that the growth rate of the index is a weighted average of the growth rates of the quantity subindexes. Each growth rate is calculated as the logarithm of the ratio of the quantities in successive years. For the output quantity index, weights are equal to the share of each quantity subindex's cost elasticity in the sum of cost elasticities for all outputs. Cost elasticities were estimated in our econometric work. For the input quantity indexes, data on the average shares of each input in the aggregate applicable total cost of sampled distributors during these years are the weights.

A.1.2 Output Quantity Subindexes

Output quantity subindexes were total gas delivery customers and gas delivery volumes.

A.1.3 Input Quantity Subindexes

The quantity subindex for labor was the ratio of the aggregate labor expenses to a BLS index of regional labor cost trends. The quantity subindex for other O&M inputs was the ratio of aggregate expenses for other O&M inputs to the GDPPI. The approach to quantity trend measurement taken in each case relies on the theoretical result that the growth rate in the cost of any class of input j is the sum of the growth rates in appropriate input price and quantity indexes for that input class. Thus,

$$growth\,Input\ Quantities_j = growth\,Cost_j - growth\,Input\ Prices_j. \qquad [10]$$

The quantity subindexes for capital are discussed immediately below.

A.1.4 Capital Cost

A service price approach was chosen to measure capital cost. This approach has a solid basis in economic theory and is widely used in scholarly empirical work.[5] It facilitates the aggregation for purposes of industry TFP research of cost data for utilities with different plant vintages.

In the application of the general method used in this study, the cost of a given class of utility plant j in a given year t ($CK_{j,t}$) is the product of a capital service price index ($WKS_{j,t}$) and an index of the capital quantity at the end of the prior year (XK_{t-1}).

$$CK_{j,t} = WKS_{j,t} \cdot XK_{j,t-1}. \qquad [11]$$

Each capital quantity index is constructed using inflation-adjusted data on the value of utility plant. Each service price index measures the trend in the hypothetical price of capital services from the assets in a competitive rental market. In our gas distribution research for BoGas, there is only one category of plant: gas plant.

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[4] For seminal discussions of this index form see Törnqvist (1936) and Theil (1965).

[5] See Hall and Jorgensen (1967) for a seminal discussion of the service price method of capital cost measurement.

In constructing indexes we took 1983 as the benchmark or starting year. The values for these indexes in the benchmark year are based on the net value of plant as reported in the USR. We estimated the benchmark year (inflation adjusted) value of net plant by dividing this book value by a "triangularized" weighted average of the values of an index of utility asset prices for a period ending in the benchmark year. Values were considered for a series of consecutive years with length equal to the lifetime of the relevant plant category. A triangularized weighting gives greater weight to more recent values of this index, reflecting the notion that more recent plant additions have a disproportionate impact on book value.[6] The asset-price index (WKA_t) was the applicable regional Handy-Whitman index of utility construction costs for the relevant asset category.[7]

The following formula was used to compute subsequent values of the capital quantity index:

$$XK_{j,t} = (1 - d) \cdot XK_{j,t-1} + \frac{VI_{j,t}}{WKA_{j,t}}. \qquad [12]$$

Here, the parameter d is the economic depreciation rate and VI_t is the value of gross additions to utility plant.

The economic depreciation rate was calculated as a weighted average of the depreciation rates for the structures and equipment used in the applicable industry. The depreciation rate for each structure and equipment category was obtained from the Bureau of Economic Analysis (BEA) of the U.S. Department of Commerce. The weights were based on net stock value data drawn from the same source.

The full formula for a capital service price index is:

$$WKS_t = \left(CK_{j,t}^{taxes} / XK_{j,t-1}\right) + r_t \cdot WKA_{j,t-1} + d \cdot WKA_{j,t} - \left(WKA_{j,t} - WKA_{j,t-1}\right). \qquad [13]$$

The four terms in this formula correspond to the four components of capital cost in a competitive industry. These are: taxes, the opportunity cost of capital, depreciation, and

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[6] For example, in a triangularized weighting of 20 years of index values, the oldest index value has a weight of 1/210, the next oldest index has a value of 2/210, and so on. 210 is the sum of the numbers from 1 to 20. A discussion of triangularized weighting of asset price indexes is found in Stevenson (1980).

[7] These data are reported in the *Handy-Whitman Index of Public Utility Construction Costs*, a publication of Whitman, Requardt and Associates.

capital gains.[8] Here, $CK_{j,t}^{taxes}$ is total tax payments. The term r_t is the cost of funds. As a proxy for this we employ the user cost of capital for the U.S. economy.[9] This reflects returns on equity as well as interest rates. We calculate the user cost of capital using data in the National Income and Product Accounts (NIPA). The accounts are published by the BEA in its *Survey of Current Business* series. Capital gains are smoothed using a three-year moving average.

A.1.5 Output and Input Quantity Results

Detailed input quantity results can be found in Table 5 and 6. It can be seen that gas customers in the Northeast grew by 1.1% per annum while delivery volumes grew by 2.5% per annum, in average, over the 1990-2000 sample period. The index of output quantity grew by an average for 1.4% annually over this period. Turning to input

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[8] The opportunity cost of capital is sometimes called the cost of funds.

[9] The U.S. economy user cost of capital is not directly observable, but it can be measured by applying two economic relationships. The first economic pertains to the National Income and Products Accounts (NIPA) definitions of Gross Domestic Product (GDP) and the cost of inputs used by the U.S. economy. In the NIPA, the total cost of the U.S. economy inputs is equal to GDP. At the economy-wide level there are two inputs: labor and capital. Therefore the total cost of capital is equal to GDP less Labor Compensation (CL), or:

$$CK = GDP - CL \tag{1}$$

where CK represents the total cost of capital. The second relationship is between the total cost of capital and the components of the capital price equation. The total cost of capital is equal to the product of the quantity of capital input and the price of capital input, or:

$$CK = P_k \cdot K \tag{2}$$

where P_k represents the price and K the quantity of capital input. The price of capital can be decomposed into the price index for new plant and equipment (J), the opportunity cost of capital (r), the rate of depreciation (d), the inflation rate for new plant and equipment (l), and the rate of taxation on capital (t):

$$P_k = J \cdot (r + d - l + t) \tag{3}$$

Combining (2) and (3) one obtains the relationship:

$$\begin{aligned} CK &= J \cdot (r + d - l + t) \cdot K \\ &= r \cdot J \cdot K + d \cdot J \cdot K - l \cdot J \cdot K + t \cdot J \cdot K \\ &= r \cdot VK + D - l \cdot VK + T \end{aligned} \tag{4}$$

where D represents the total cost of depreciation, T total indirect business taxes and corporate profits taxes, and VK the current cost of plant and equipment net stock. Combining (1) and (4), one can derive the following equation for the opportunity cost of capital:

$$r = (GDP - CL - D - T + l \cdot VK) / (VK) \tag{5}$$

GDP, labor compensation, depreciation, and taxes are reported annually in the NIPA. The current cost of plant and equipment net stock and the inflation rate for plant and equipment are not reported in the NIPA, but are reported in <u>Fixed Reproducible Tangible Wealth in the United States</u>.

Table 5

Output Quantity Index: Northeast Gas Distributors

	Output Quantity Index	Retail Customers	Total Retail Deliveries
1990	1.000	1.000	1.000
1991	1.007	1.008	1.004
1992	1.046	1.016	1.144
1993	1.067	1.025	1.210
1994	1.080	1.037	1.226
1995	1.106	1.048	1.310
1996	1.108	1.051	1.307
1997	1.135	1.067	1.376
1998	1.126	1.087	1.258
1999	1.133	1.092	1.270
2000	1.152	1.113	1.285
Average Annual Growth Rate 1990-2000	1.42%	1.07%	2.51%

Table 6

Input Quantity Index: Northeast Gas Distributors

	Input Quantity Index	Capital	Labor	Other O&M
1990	1.000	1.000	1.000	1.000
1991	1.024	1.032	0.968	1.089
1992	1.035	1.053	0.967	1.078
1993	1.052	1.078	0.970	1.093
1994	1.060	1.100	0.969	1.061
1995	1.066	1.125	0.908	1.101
1996	1.078	1.145	0.895	1.127
1997	1.066	1.165	0.860	1.022
1998	1.058	1.181	0.829	0.956
1999	1.067	1.194	0.862	0.906
2000	1.093	1.209	0.766	1.178
Average Annual Growth Rate 1990-2000	0.89%	1.89%	-2.66%	1.64%

quantities, it can be seen that the quantity of capital services grew by about 1.9% annually. The quantity of labor services fell by 2.7% annually, while the quantity of other O&M inputs rose by 1.6%. These results probably reflect some substitution of capital and other O&M inputs for labor during the sample period.

A.2 TFP Growth Rates and Trends

The annual growth rate in the TFP index is given by the formula

$$\ln\left(\frac{TFP_t}{TFP_{t-}}\right) = \ln\left(\frac{Output\ Quantities_t}{Output\ Quantities_{t-1}}\right) - \ln\left(\frac{Input\ Quantities_t}{Input\ Quantities_{t-1}}\right). \qquad [14]$$

The results featured in Section 2 are for the long-run trends of the indexes. Since the index formulas involve annual growth rates, some method is needed to calculate long run trends from the annual growth rates. The long run trend in each TFP index was computed using the formula

$$trend\,TFP_t = \frac{\sum_t{}_{1990}^{2000} \ln\left(\frac{TFP_t}{TFP_{t-1}}\right)}{10} = \frac{\ln\left(\frac{TFP_{2000}}{TFP_{1990}}\right)}{10}. \qquad [15]$$

It can be seen that the long run trend is the average annual growth rate during the years of the sample period. The reported long run trends in other indexes and subindexes were computed analogously.

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